CAPTIVE BREEDING OF THE EUROPEAN MERLIN *(Falco columbarius aesalon)*

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Abstract - Two pairs of the European Merlin (*Falco columbarius aesalon*) were established in two contiguous Hurrell-type skylight and seclusion breeding pens in 1977. One male had been taken from the wild, the other 3 were captive-bred F_1's. Both males were in adult plumage but the females were sub-adult. All had been manned and were tolerant of limited intrusion that became necessary. A choice of nest site between an artificial crow's nest and a roofed open nest-box was provided in each pen. The crow's nest was chosen in one pen, the nest-box in the other. Provision of ground sites was considered to be unnecessary. Nest-site selection, food passing, mating, egg-laying, incubation and hatching are described, followed by feeding and development of the young. One pair laid 4 eggs; 1 hatched. The other laid 5 eggs; all hatched. Owing to the apparent initial inefficiency of the parents in feeding newly hatched young because of interference by the male, the singleton and 2 of the brood of 5 were removed to a brooder and hand-fed until about 8 d old. The former was returned to its parents, and the other 2 were fostered with that pair. All young were reared successfully and five were issued on loan to falconers. Incubation period was between 31 and 32 d. The earliest to roost away from the nest were 2 males in their 25th d, and the latest a female in its 28th d. The males were hard-penned at about 40 d. The diet comprised half-grown surplus laboratory white mice, of which an ample deep-frozen supply was available.

This work was done at Beckhampton, Marlborough, Wiltshire.

The breeding of the European Merlin (*Falco columbarius aesalon*) in capativity in 1977 described here was not the first success in a project begun in 1971. A pair allocated to L.H. Hurrell had already bred in 1975 and 1976. Hurrell had shown a film of the breeding at the I.C.B.P. Conference on Birds of Prey, Vienna (1975), the Hawk Trust's Conference, Harrow, Middlesex (1976), and at the International Conference on Falconry and Conservation, Abu Dhabi (1976). It seemed desirable to publish a detailed account and to recognize the considerable support given by the Scottish Home and Health Department in granting a licence, in 3 successive years, to take a young Merlin from the wild for use in the project.

Breeding Material Available - Two males and 2 females of the European Merlin were used. They were a 1974 Scottish-licensed male (Lochan), a 1975 captive-bred F_1 male (Brae), and two 1976 captive-bred F_1 females (Myrtle and Corrie) from the first, kestrel-fostered, and the second, Merlin-reared, clutch, respectively, from the pair with Dr. Hurrell. This pair comprised a 1973 flight-impaired male (wild taken) (Laggan) and a 1973 Scottish-licensed female (Erica).

It should be noted that whereas the 2 males were adult approaching 3 and 2 yr old, respectively, the 2 females were not yet 1 yr old. All 4 had been previously manned and were so up to the breeding season.

Accommodation - A pair of contiguous Skylight and Seclusion pens (Hurrell *in* Mavrogordato, 1973) on a south-facing wall 2.40 m high, topped with concrete slabs, was used. Sections of the wall 4.50 and 3.30 m long formed the backs of pens 1 and 2, respectively; the sides, each 5.80 m long and 2.40 m high, were of translucent corrugated polythene, as were the 4.50 m - and 3.30 m - long south walls (Fig. 1). The roof was 45 mm square-mesh, heavy nylon netting spread 50 mm below a layer of 40 mm wire netting.

The timber-walled observation hide was in the SE corner of pen 1 and SW corner of 2, with access from outside. Access to each pen was by a small door, opening outwards from the pen into the hide.

Nest Sites - Each pen had 2 elevated nest sites; an artificial crow's (*Corvus* sp) nest with overhead shelter from rain, and an open nest-box of a shallow wooden tray 70 cm long x 35 cm from back to front x 10 cm deep with a rain-proof roof sloping from 40 cm height in front to 30 cm at the back. A landing board 20 cm wide was along the front. Nest-boxes were placed in both pens on the north-facing wall within 1.50 m of the hide in full view. In pen 2 the crow's nest was between the hide and nest-box. In Pen 1 the crow's nest was left in its 1976 position under the south-facing wall. Owing to its distance from the 2-way mirror in the hide it was necessary for this crow's nest to be no more than 0.75 m from the ground for its contents to be visible. All other sites were 2 m from the ground. Moreover, in order to see details in the crow's nest in pen 1 at this distance (about 5 m) a pair of binoculars with short range focus were useful.

In Britain Merlins usually nest on the ground in either heather (*Calluna vulgaris*) or bracken (*Pteridium aquilinum*). Therefore, much time was spent in 1971 in providing them. This proved unnecessary, however, as no pair showed any interest in ground sites. Additionally, an old crow's nest had

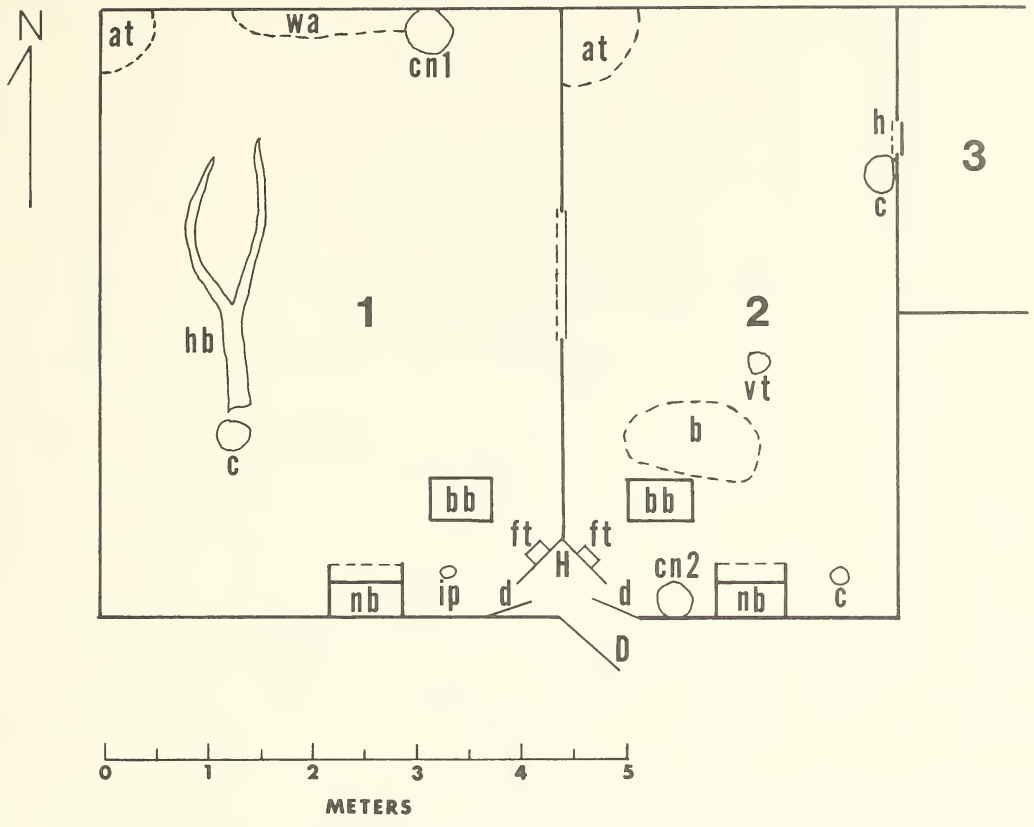

Figure 1. Plan of both pen 1 and 2. D or d - door area, H - hide, f t - feeding trays, bb - bath, nb - nest-boxes, c - cairn, cn - crow nest, a t - artificial tree, b - bracken, h - shuttered hatch, v t - vertical tree, i p - isolated post, h b - tree branch, w a - wall tree.

been placed in the top of an artificial tree (a section of a pine tree (*Pinus* sp) with the top cut out) in the pen's NW corner. A prototype of the nest-box, intended to represent a cliff site, had been attached to the south-facing wall as well.

Before the 1977 season the old crow's nest was removed because it was too high for visibility. The trees, however, continued to be used as a perch. It appeared that the natural crow's nest was not durable enough to withstand the early destructive activities of Merlins pulling at twigs and scraping in the nest cup. By 1977, a more robust artificial crow's nest was designed with a very durable cup plastered with a mixture of silt and rotted farmyard manure. The cups were partly filled with a mixture of peat and coarse sand, on the surface of which was scattered a layer of 30 - 40 - mm - long pieces of thin dry twigs. The trays of the nest boxes were similarly treated. The twig chips supplied material for the female to pick up. We observed incubating Merlins break off pieces of twig from parts of the nest within reach and drop these into the nest cup at the bird's breast. A female was seen doing this while lying in the nest long before oviposition; the male also did so, but less often.

Diet - Half-grown frozen laboratory mice were fed, but until early April 1977 day-old cockerel chicks occasionally made up 50% of the daily ration. On all such occasions the chick's yolk sac and intestines were removed and feet and tarsi cut off. The chicks were also roughly skinned and cut up into head, thoracic and pelvic portions. There were grounds for thinking that excessive intake of chick yolk was undesirable and that feet and tarsi, swallowed whole, tended not to be digested.

After early April the diet was 100% laboratory

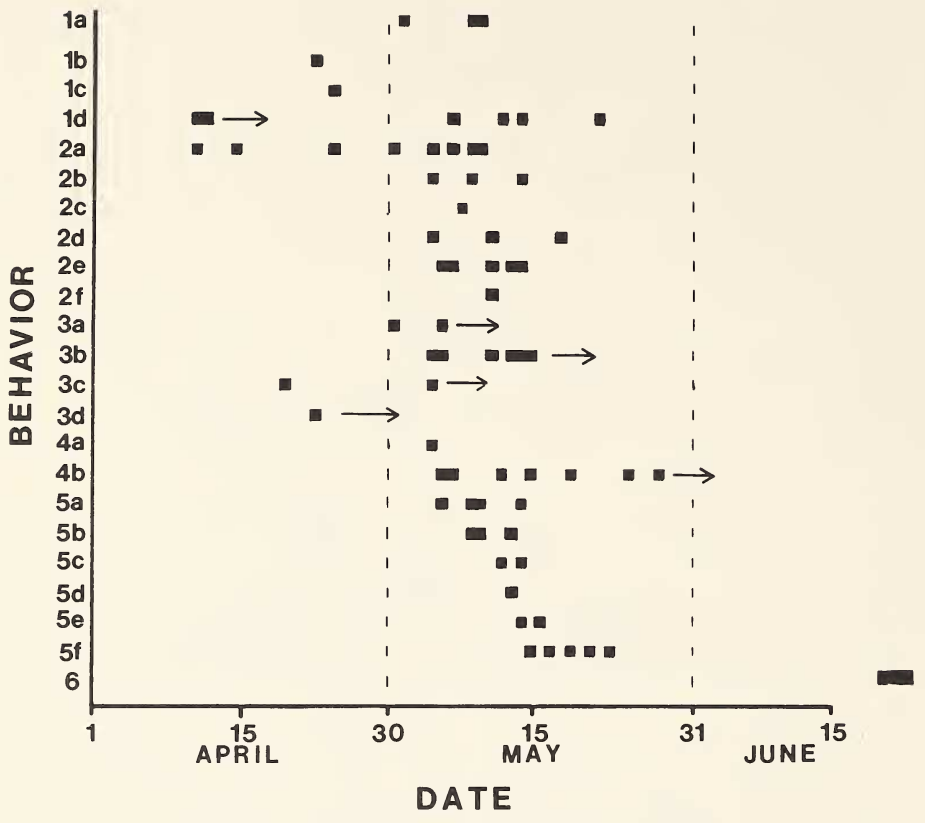

Figure 2. Sequence of behavior in No. 1 Pen. (1) a. female harassing male; b. male still mistrusting female; c. male bonding with female; d. male food caching. (2) a. male nest scraping; b. female nest scraping; c. female in scrape; d. female starts twig pulling; e. male site display; f. female site display. (3) a. male *kwi* call; b. male *kip* call; c. female *kwey* call; d. female *chup* call. (4) a. female responds to male food call; b. beak-to-beak food pass. (5) a. male mating approach; b. copulation attempt; c. successful copulation; d. oviposition lassitude; e. female pouchiness; f. eggs laid. (6) eggs hatch - 3 on 20 June, 1 on 21 June, 1 on 23 June.

mice. The adults did not pluck the mice very thoroughly, although it was noticed that as the breeding season approached more extensive plucking was done, particularly by the male when food passing had begun. Therefore, for the first 10 d after hatching of the young, all mice, except those put in after dark for the early-morning feeding, were 'prepared' to reduce the ratio of fur to flesh in each food item. In what came to be known as "Mark I (MK I) prepared," the mouse head was removed, the body skin loosened from the body, which was pushed further into the skin and the surplus skin cut off. In "Mark II," the headless body of a rather smaller completely skinned mouse was packed in on top of a MK I preparation, the neck skin of which was then tied with white cotton thread, thus further reducing the ratio of fur to flesh.

In the present study, preparation of MK II mice was used. It seemed that feeding of young ended when the food item had been distributed to them rather than when their hunger had been satisfied. Therefore, the larger size of the MK II mouse was likely to be beneficial.

Making up of Pairs - The 1975 captive-bred F_1 male (Brae) had been in pen 2 with 2 sibling males for over 1 yr by 4 December 1976 when the 2 latter were removed. The 1976 captive-bred F_1 female (Myrtle) was then introduced. They had settled down together within a week. Circumstances did not permit the release of the 1974 Scottish male (Lochan) into pen 1 before the 1976 captive-bred F_1 female (Corrie) had become established there. He had been familiar with pen 1 and, when introduced

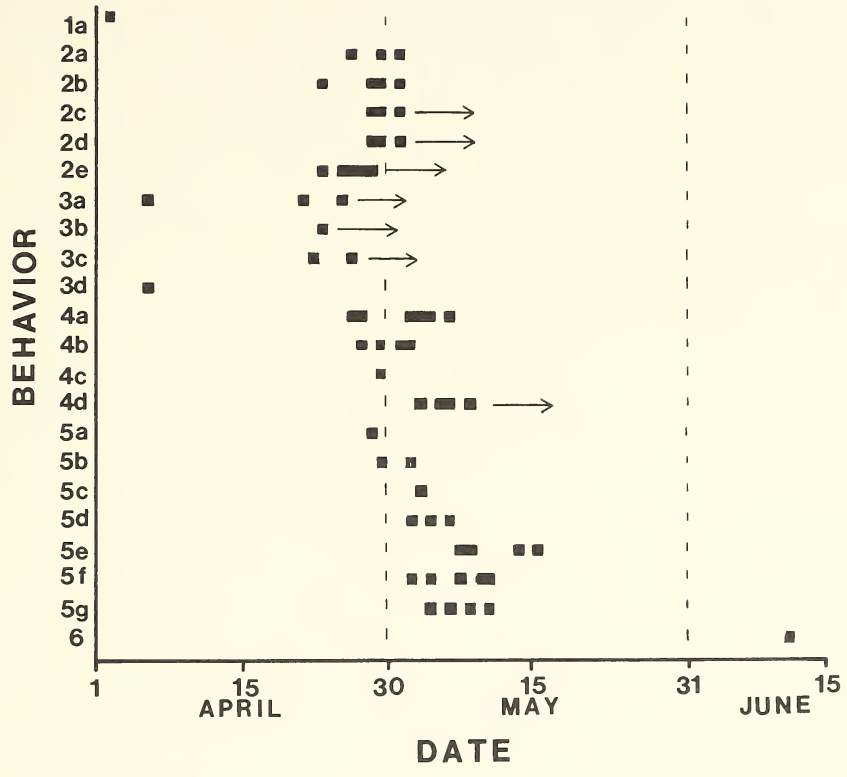

Figure 3. Sequence of behavior in No. 2 Pen. (1) a. male food caching. (2) a. male nest scraping; b. female nest scraping; c. female on scrape; d. female twig pulling; e. male site displays. (3) a. male *kwi* call; b. male *kip* call; c. female *kwey* call; d. female giving young call. (4) a. female takes food from cache; b. male offering food; c. attempted male/female food pass; d. successful beak-to-beak food pass. (5) a. male mating flights at female; b. female deters mating flights; c. apparently successful copulation; d. as in b; e. other successful copulations; f. oviposition lassitude; g. eggs laid. (6) first egg hatched. (remainder infertile).

on 6 February 1977, seemed at first to hold his own but soon became nervous of Corrie, particularly when he had food, on which occasions she was liable to harass him. Reasonable accord was not achieved until towards the end of March and full confidence was not shown until the end of April.

Observations - Regular daily observations on both pairs were made, particularly at feeding time. The sequence of the more important steps up to and including egg hatching is shown separately in Figures 2 and 3.

Although egg-laying began earlier in pen 2 than in pen 1, the cycle in pen 1 is shown in Figure 2 before that in pen 2 (Fig 3) because there were more apparent abnormalities in the latter.

The only apparent irregularity in pen 1 was the delayed start of caching food by the male (Fig 2, 1d) by about 9 d, as compared with pen 2 (Fig 3, la) which might be attributed to persistence of harassment of the male by the female (Fig 2, 1a, 1b). When it did take place, it did not initiate the food pass, the latter taking place on the day following the first observed occasion of the male's calling *kwi* . . . with food in his beak. The food pass (4b) took place with its accompanying *kwi* and *kwey* calls (3a, 3c) while nest-site selection (2e, 2f) was still going on. The food pass was quickly followed by mating approach flights (5a), the early ones of which were deterred by the female. A possibly successful mating took place after 3 d (5b), and probably successful ones 2 d later (5c).

Oviposition lassitude (5d) was evident 3 d after the first observed possibly successful mating; and sagging of the abdomen (pouchiness) (5e) on the

following day. On the next day the first of 5 eggs (5f), laid at 48-h intervals was seen. Dates of laying were 15, 17, 19, 21, 23 May. Three hatched on 20 June before 1100 H, 1 on 21 June by midday, and the final 1 on 23 June. This suggests that incubation began 1 d before egg No. 4 was laid, giving an incubation period of 31-32 d.

In pen 2 the breeding cycle was delayed after nest-site selection by the prolongation of the stage of food caching by the male and collection by the female ("remote food passing" of Nelson 1977, quoted by Cade, 1982, p. 25). This was due to the failure of the female to respond adequately for over a week (4b) to food items offered by the male. There was a further delay (5a, b, d) before apparently successful mating took place (5e), by which time oviposition lassitude had been apparent for 5 d (5f), and two eggs had been laid (5g). This delay might account for the infertility of 3 of the 4 eggs.

During oviposition lassitude, about 3 d before the first egg was laid, the female performed a movement (8 in 1d), here termed 'dunking', similar to that made when sousing the under-tail coverts during bathing. It was difficult to be certain when incubation began, but it probably did not until 11 May, the day on which the fourth and last egg was laid.

Site-Selection Display - On arrival at the scrape the male held his wings high over his back for a moment, with the tips pointing upwards. In the complete pattern the male then partly lowered the wings and walked about on the nest in a stilted manner for a short time before starting to bow towards the female. In this, the head, body, and partly open wings would be aligned horizontally in her direction with the tail, usually partly fanned, cocked up at an angle. At the bottom of the bow, the wing tips and tail were pointing upwards at an angle of perhaps 30°. The soft *kip* call would be uttered during bowing.

Mutual bowing displays over the nest scrape occurred occasionally. Male bowing in the nest scrape while holding a mouse in his beak occurred and was probably part of food-pass display. On 3 May, before beak-to-beak passing had been achieved in pen 2, the male was doing this, and then deposited the mouse in a corner of the nest-box. After he had done so, the female arrived and took the mouse. He flattened out in the scrape with wings slightly open and held this position until the female moved slowly to the front of the nest-box and flew to the other end of the pen. He had been seen in a similar position on 2 May with the female standing alongside and later settling down in a lying position. She nibbled at his beak.

The crows nest was used in pen 1 and the nest-box was used in pen 2.

Food Caching by the Male - This might take place either as initiation of the food pass ("remote food passing") or when for any reason the male had a food item not required by the female.

In the former case the site chosen was where the female could see what he was doing; in the latter it was usually in a more concealed position. The food item, still in the beak, would be deliberately pushed into the chosen position and left there, after which the male would stand up tall, looking intently at it, then back away a few steps before leaving.

Mating Approaches and Mating - The male indicated his intention to make an approach by stretching his head forward, sleeking his body feathers and slightly opening the wings in the plane of the body. The tail was held lower than the plane of the body, giving an arched-back effect. He stared in the direction of the female, and on taking off in flittering flight, uttered a specific, single, rather drawn-out call, *kwark*. If the female was prepared to accept him, she assumed a horizontal position and remained steady as he mounted; he might maintain his position by beating his wings. If, however, she intended to deter him, she uttered a single call, *koi*, or gave some unidentified signal, which may have been failure to adopt the accepting attitude.

On only 2 occasions was a call heard during mating, uttered by the female, which could only be recorded as either *kwey . . . kwek* or something resembling the young food-call (*eep . . .eep*).

Protest Flying - In April increasing evidence of territorial awareness was marked by what may be described as 'protest flying' against low overflying birds. Both of a pair, or both pairs, would suddenly start flying wildly around the pen, sometimes throwing themselves feet upwards against the roof netting, and uttering calls of anger or alarm, (*kek, kek, kek . . .*).

Even after incubation began the sitting bird would come off and take part. The protests seldom lasted more than 1 min, and eggs were usually quickly covered again. The female in pen 1 reacted more strongly to intruders than did the others.

Feeding of the Female during Incubation - During incubation the male provided most but not

all of the female's food. He took mice from the feeding tray to a regularly used plucking perch. When it was adequately plucked he called *kwi . . . kwik* and awaited a positive response, the *kwey . . .kwek* call of the female and her arrival to receive it there. Occasionally he transferred food at the nest. The female ate the item away from the nest and the male would promptly cover the eggs. After feeding, the female sometimes did not return to incubate immediately. If there was no response from the female to the male's call, he would either eat the mouse or cache it.

Hatching - Signs of possible approach of hatch were noted in pen 2 on 10 June (probably d 31 of incubation) although no pipping of the eggs could be seen. The female was doing a greater share of the incubation, was reluctant to come off when given a food item, and later would not allow the male to take over incubation. She was doing an unusual amount of looking down towards the eggs, and continued to draw in twig chips. Twice on the following day both birds were in the nest scrape. One young was seen at 1500 H.

In contrast, the pair in pen 1 showed no air of expectancy at the corresponding time and on d 30 of incubation the female left the eggs uncovered, after having come off to feed, for intervals of 5-7 min.

Feeding of the Young - In pen 1 the first hatchling was seen at 0700 H. The first observed feed took place at 1030 H, by which time there was a second young, which also received food. Altogether, 5 feedings were seen between 1000-2050 H on d 1. Intervals between known consecutive feedings ranged from 1 to 1½ h. At a later date (d 11), 7 feedings were observed. Times between known consecutive feedings ranging: ¾ h, 1 h, 1 h, 1 h.

Interference by the male, usually an interception and eating of food morsels that were being offered the young, took place frequently from d 2 until about d 6, when at least some of the intercepted morsels were passed to the young.

In pen 2 no further egg hatched after 1 on d 32. Interference by the male was more disruptive and on d 3 the young was temporarily removed for hand-feeding. The parents continued to incubate the remaining eggs.

By d 4, it seemed that the youngest (No. 4) in pen 1 was not getting enough food in competition with the 3 older siblings. It was removed to a brooder for hand-feeding. In anticipation of similar difficulty with young No. 5, it was removed as soon as possible after hatching. These 2 young were subsequently fostered into pen 2 on d 11 and 12.

In spite of the early interference, the males continued their plucking and offering of mice (now all MK II prepared) to females as they had done during incubation. During the first week, the male transferred food at the nest, but thereafter she flew to him on his plucking perch when he called.

In pen 1, full co-operation with the female in feeding was established by d 11. The male was first seen feeding alone on May 14, and on d 20, each parent took a mouse to the nest at the same time and distributed morsels separately. In contrast, the male in pen 2 was seen feeding alone only once. When offering morsels of food, the female used a single, soft *chup* call, of which the male's version was *kip*.

Development of the Young - Development of the young in pen 1 is shown in Table 1. When first hatched, they were covered with white down through which body colour was partly visible, giving the impression that the down was faintly pink in colour.

The eyes appeared to be sufficiently open for the young to see and snap at food morsels on d 4. Their movement in response to temperature coincided with being left uncovered at intervals from d 8 onwards. Parents shaded them during midday heat. On d 13 we provided overhead shade for the nest. This was providential because between d 13-18 a very hot spell occurred with temperatures reaching 27.5°C.

On d 19 a ladder was installed from the ground to the nest, and it was used on d 24 to 25 by the young to regain the nest. Within a further 2 d, 2 young roosted away from the nest. Although they were able to break up a food item effectively from d 24-26 they were still fed up to d 30. It was expected that they would be hard-penned soon after primary No. 9 (counted from carpal joint outwards) was as long as No. 8. This occurred at about d 38-40. The rates of growth for Nos. 4 and 5, while being hand-fed are shown in Table 2, and some weights for all 5 are given in Table 3.

The development of the single female that hatched in pen 2 is shown in Table 4. The continued incubation of the remaining eggs facilitated the return of it after being hand fed from d 3 - 9. The unhatched eggs were infertile. Although the

hand-fed male young were about 12 d younger than the female in pen 2 they were adopted. The female young did not roost away from the nest until d 28.

The hand-fed young (Table 2) were accommodated in the brooder in a shallow bowl lined with tissue paper surrounded by a bound ring of twigs. They were given 8-9 feedings between 0700 and 1300 H of the following day. No. 4 was returned to parents on its 8th d, but was transferred to pen 2 on its 11th d. No. 5 was fostered direct from hand-feeding to pen 2 on its 8th d.

Table 1. Development and progress of the nestlings in No. 1 Pen.

FEATURE	DAY NUMBER (FROM HATCHING OF NOS. 1-3)
Hatching of Nos. 1-3	1
Hatching of No. 4	2
Hatching of No. 5	4
No. 4 removed for hand-feeding (aged 2d)	4
No. 5 removed for hand-feeding (aged a few hours)	4
Nestlings left uncovered at intervals	8
Movement of nestlings on nest in response to temp	8 →
Wing-flapping and rousing	8
Close ringing	8 - 9
Parents shade young in midday heat	8, 10, 11
No. 4 returned to pen	9
No. 5 fostered direct from hand-feeding into No. 2 pen	11
No. 4 transferred to No. 2 pen	12
Overhead shade provided for nest	13
Hot spell (shade max. 24-27.5°C)	13-18
Sitting up on tarsi prolonged	14
White down superseded by smoky grey	11 - 14
Rectrice tips and remige quills visible	13 - 14
Active interest in movements of parents	15 - 16 →
Standing up on feet; begin to walk	17
Increase in wing-flapping	17
Walking actively on nest	19
Ladder from ground to nest installed	19
Two nestlings perched outside nest in contiguous tree (Fig. 1 wa)	22
One nestling on ground (returned by hand)	23
Parents leave food for nestlings to break-up (with partial success)	23
Two pale bands visible on tails	23
Two nestlings on ground; one bathed; both returned to nest by ladder	24
Nestlings break-up food effectively	24 - 26
All 3 nestlings on ground; 2 colour-ringed	25
The two more advanced nestlings roost away from nest	25
Flying activity progresses	26 →
Much time spent lying on nest or elsewhere, apparently asleep	26 - 38
Last occasion when a parent feeds morsels to a nestling	30
A nestling takes food from tray	29
A nestling caches food item received from parent	30
Nestlings believed to be hard-penned	38 - 40
Nestlings taken up for training	40 - 41

Table 2. Routine weighings of two nestlings hand fed up to day eight.

	Weight(g) and Time Day							
Nestling	1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	8
4 *	-	@21 2015	@25 0700	30 0700	40 0630	50 0745	65 0745	80 0700
5**	@10 1630	12 0700	18 0700	25 0630	30 0730	40 0700	50 0700	65 1345

* Nestling 4 removed from parents on day 1 at 1430 H.
** Nestling 5 removed from parents when a few hours old.

Calls - These have already been mentioned in the text as they occurred and are listed below:

(1) *Kip:* This soft call, usually repeated rhythmically at 1 - 2 sec intervals, is used by the male in several connections in the breeding season:

(a) When he is plucking a food item preparatory to offering it to the female or eating it himself and he will continue to call as he feeds.
(b) When scraping in a nest site.
(c) In nest-site selection bowing display.
(d) When he wants to take over on the nest.
(e) When doing his share in feeding of the young.

Campbell and Nelson (1975) describe two forms, 'Chip or Tick' and 'Soft Chip or Tick', attributing the latter to the female when feeding young. As shown below, the latter has been represented by *chup*, which Campbell and Nelson interpret as a deterrent used by the female on the nest, but was not noticed here in this connection. Rowan (1921-22) mentions a very soft monosyllabic *tick* uttered by both birds on arrival at the nest, but he makes no mention of its use when the female was feeding young, yet his hide was only 2.5 m from the nest.

(2) *Chup:* Believed to be the female's version of *kip* and used:

Table 3. Weights showing rate of growth of nestlings in No. 1 Pen.

	Weight(g) Day								
Nestling	8	10	11	12	25	40	41	49	55
1	80	—	—	130	@198	—	178	—	—
2	80	—	—	140	@198	—	188	—	—
3	60	—	—	—	—	170	—	—	—
4*	80	—	120	—	177**	—	—	165	
5*	65	105	—	—	—	—	—	—	@170

* Nestlings 4 and 5 were hand fed in a brooder for the greater part or all of their first eight days.
** Nestling 4 weighed on day 24.

Table 4. Development and progress of the nestling in No. 2 Pen.

FEATURE	DAY NUMBER
One egg hatched	1
Male disrupts attempts at feeding	1 - 3
Nestling removed for hand-feeding	3 (evening)
Parents continue to incubate remaining eggs	4 - 10
Infertile eggs removed and nestling returned to parents	10
Male becoming less disruptive at feeds	11
Male sometimes leaves nest after handing over of food	11 →
Nestling being frequently left alone during day	14
At dusk, female crouching over or beside nestling	14
Remige quills beginning to show on nestling	14
Hand-fed nestling No. 5 of No. 1 Pen fostered	20
Nestling No. 4 fostered from No. 1 Pen	21
All 3 nestlings still huddle together for night	23 - 26
Nestling No. 1 actively playing with twigs, etc.	24
Nestling No. 1 actively wing-flapping	24
For some days male would frequently return to nest and rob female of food item, which she might retrieve or that he would return	24 - 28
Nestling No. 1 returned to nest in evening via ladder	27
Two pale bands showing on tail	27
Nestling No. 1 breaks up a mouse, also later accepts morsel	28
Nestling No. 1 to a high perch in evening, probably roosted there	28
Transferred to separate pen	29
Taken up for transfer to a falconer (not yet fully hard-penned)	37

(a) When plucking, and feeding herself, or the young in the nest.
(b) It is probably used when taking over from the male on the nest.
(c) In mutual bowing in nest site.

(3) *Kwi, kwi, kwi, kwik:* A single syllable, rapidly repeated 4 or 5 times. Used by the male particularly when he has plucked a food item and intends to offer it to the female, but sometimes used when he has no food item. This, and the female's version, *kwey . . .kwek* are undoubtedly the 'Short Chatter' of Campbell and Nelson.

(4) *Kwey, kwey, kwey, kwek:* Believed to be the female's version of *kwi . . .kwik* and used in response to it to indicate that she wants to receive the item. It may be used to draw the attention of the male to her need for food. The 2 calls were very frequently used in mutual responses by a pair in a previous season without food being involved.

It is strange that the female of the pair studied in the wild by Rowan (1921-22) responded to the male's 'Short Chatter' with what appeared to be a form of the young food call, and not with her version of the 'Short Chatter'. The 'Short Chatter' of male and female were the most characteristic and frequently heard calls during the breeding season in the present study. There is, however, a very similar call, but rather shriller in the male and harsher in the female, that appears to be used to give the opposite message, "I have food, keep away." It was usually heard early in the year. It was once heard, in May 1974, from a female under circumstances suggesting territorial advertisement to another female.

(5) *Kwark:* A single, drawn-out call uttered by the male just before flying towards the female in a mating approach.

(6) *Koi:* A single, brief call, seldom heard but apparently given by the female to deter the male from a mating approach. The call had been heard 3 times in 1975, twice in the context of mating approaches and once when the male, of a pair in which the

female had consistently evaded mating, alighted close to the female without any apparent mating intent on 23 May. He departed almost at once. On only 2 occasions was any call heard during mating, on 7 and 9 May, both after egg-laying began. The call was given by the female and could only be recorded as either *kwey . . . kwek* or the young food call. It is possible that it may have been something specific.

(7) *Eep, eep, eep . . . :* The young food call, heard after they had left the nest, associated with an adult having food. Also used by the female in pen 2 occasionally in March and early April, and again in the succeeding autumn.

(8) *Kek, kek, kek . . . :* The alarm call, rapidly and continuously repeated. This is the 'Aggressive Chatter' of Campbell and Nelson.

Discussion

Campbell and Nelson (1975) found their Merlins (*F. c. richardsoni*) hypersensitive to human interference, which caused aggression, sometimes fatal, by the female towards the male. Campbell (1980) suggeted that if Merlins were well manned, they would be less hypersensitive. This was well demonstrated in the tolerance in the 2 pairs as exemplified by the female in pen 2 having had to be pushed/lifted off the fostered young that she was brooding in order that a second one might be introduced. None of the Merlins had been given any occasion to become imprinted on man when young, but all had been manned at one time or another. Outside the breeding season they would, given a few days' practice, come to the fist in their pens.

Campbell (1980) moots the thought that aggression he saw might have been due to putting the Campbell and Nelson (1975) birds together too early, or leaving them together throughout the non-breeding season. A little information on this point was obtained early in 1977, when Heather, a sibling female of Myrtle (female of pen 2) was returned on 20 February because of aggression towards the male with which she had been paired elsewhere. She was isolated in a small pen that had a small, shuttered communicating hatch into pen 2 with watching perches placed within 30 cm of it in each pen. On 22 April 1977 the blank shutter was lowered, leaving only a nylon mesh shutter between the 2 pens. Almost immediately, Brae and Heather were face to face on opposite watching perches, evincing interest but no threat, and both at one time or another tried to get through to the other side. Myrtle on arrival, made a fierce attack on Heather across the barrier, to which the latter responded equally fiercely. The blank shutter had to be hauled up quickly. On 26 April, Heather was transferred to be paired with a leg-impaired haggard male. Breeding did not take place, but nor did harassment.

It seems possible, therefore, that if the introduction between Lochan and Corrie had been deferred until March-April and done more gradually, less aggression might have resulted. A trial in 1975, aimed at simulating the usually sequential spring arrival of male and female Merlins on the breeding grounds (Brown & Amadon 1968; Cade 1982) showed the feasibility of a 2-stage introduction of a male, isolated in pen 1 to a female in pen 2 by manipulating in March-April a double-shuttered hatch such as that described above.

Corrie, paired with Ben (a sibling of Brae) in 1979 and 1980, reared young, but during the first week of April 1981 she killed him without warning. It may be significant that during the breeding season Corrie reacted more strongly to low over-flying birds than did the others.

It has been the practice in this project to keep pairs of Merlins together throughout the year; and, up till the end of 1982, this was the only fatality of this kind that occurred. But it appears that there is a latent danger of violence just before or during the early stages of the breeding cycle, which might be triggered by human interference and possibly by other factors.

The breaking off of pieces of twigs from the perimeter of the nest and/or the drawing in of twig chips and dropping them into the nest scrape is of particular interest, although its purpose is not clear. When first observed before 1977, it seemed clear that this could account for the fact recorded in the ornithological literature that Merlin nests on the ground in the wild are often lined with heather stalks and bents. It appears that it was not until the work in Northumberland (Newton et al. 1978) that Merlins in the wild were actually recorded as placing such items, picked up from within reach, into the nest scrape, beginning before laying and continuing into incubation. Nibbling of thick heather stems by the sitting bird also occurred at many ground nests (Newton et al. 1978). In any case, whatever the purpose, it seems desirable to provide

twig chips in nest sites.

Flattening out in the scrape, by the male in the presence of the female, which nibbled at his beak, is probably a form of 'Fixed Bow' derived from mutual courtship bowing over the nest cup or scrape. Cade (1982) believed the latter to be conducive to mutual familiarization at close quarters. Flattening out was seen in a remarkable degree in 1975 between Laggan and Melanie, perhaps because there seemed to be some obstacle to Melanie's acceptance of mating approaches by Laggan. It was first observed and took place several times on 7 May. By this time beak-to-beak food passing was well established, with the female frequently passing the item back to the male. Mutual calling *kwi, kwey* was also frequent, but Melanie had consistently deterred mating approaches. Flattening out was usually initiated by the male calling *kip* in the crow's nest in pen 1 followng which the female would join him, but sometimes the female might be there already. They would bow towards each other calling *kip* and *chup* before both birds, the female in the nest cup, flattened out with the tail partly fanned and raised at an angle of ca 30°. Both birds might remain 'frozen' in this position for up to 5 min. The male would usually stand sooner, remain looking at the female for up to 1 min, as though doubtful what to do, before flying away. The female then usually stood up also. Mating did not follow any of these sessions. They continued to be seen sometimes up to 5 or more times a day, until 26 May, 2 d before Laggan was transferred.

Cade (1982) mentions that a female falcon indicates her readiness to mate by turning away from the male, which presumably facilitates his mounting. However, this turning away was not seen in the Merlins. It was noticed that matings appeared to be more consistently successful when the female was not perched on a high horizontal perch parallel to the back wall but on an isolated post, thus permitting the male to approach from any direction.

The Hurrell-type pens proved ideal for their purpose. The only potential hazard is accumulation of snow on the roof netting in winter. In the normal winter climate of southern England all that should be necessary is to go in with a forked stick and shake down the snow. In construction of Hurrell-type pens in the northern hemisphere it would be desirable to place the observation hide in the southern wall and the nest sites adjacent to it in order to avoid excessive insolation of the latter and provide optimum viewing.

ACKNOWLEDGEMENTS

The author is grateful to the Advisory Committee on the Protection of Birds for Scotland of the Scottish Home and Health Department for licences to take wild Merlins. Particularly we thank the late George Waterston, O.B.E., LL.D., for his interest, encouragement and support; the Highland Wildlife Park, Ltd., for the loan of a flight-impaired Merlin and to D.G. Hunter of the Agricultural Research Council for making available the deep-frozen laboratory mice, and to members of his staff, R.J. Taylor for making the necessary arrangements, and D. Shirt and S. Collis who handled the mice. A more extensive draft of this paper is on deposit with the Hawk Trust in Great Britain.

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